Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 4, Issue 2; January-March, 2017, pp. 114-117

http://www.krishisanskriti.org/Publication.html

Modelling, Simulation and Optimization of Steam Trap

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Abstract—*These days' process industries are becoming steam base industry, that is, high pressure steam is used for their utilization in different aspects. The steam is produced in the boilers and with the help of steam networking, it is feed to the desired machine for utilization. Due to this networking, different types of losses take place. Because of which steam efficiency get reduced. So to extract the low efficient steam, at the outlet of the network STEAM TRAPS are used. Steam Traps are nothing but just an automatic valve design to trap steam and discharge condensate. The main function of steam trap is to discharge the condensate as soon as it is formed without consuming steam. But the main problem faced in the industries are the puncture of the float ball which are present inside the trap. This take lots of time for changing the ball, due to which production get hamper as the machines are to be stopped during the changing process. This project is focused on the designing, analysis and rectification of float ball steam traps to reduce the failure of the traps and optimize the maintenance timing. With the help of experimental data and modelling improvisation the benefits like time saving, acceleration in production and decrease in maintenance cost can be done.*

1. INTRODUCTION

As per the industrial revolution, these days steam is accepted as the means of transmitting energy because of its versatile nature. Number of properties are there which make steam as the most useful and economical working fluid. Mainly high pressure steam is used in industries. It has been observed that most of the industries are totally depended on steam for their survival. Industries like paper, sugar, textile industries, power plants, process industries, etc. are using steam for running heavy machineries and many more purposes. Steam is considered the best power generating component. The steam is produced in the boilers and with the help of pipelines these steams are brought to different machines as per the use. This connection of pipelines which bring the steam from the boiler to the machines are called Steam Network. The process of transferring steam from the boiler to the respected place causes numerous losses which make the steam less efficient. In other words we can say that the quality of steam required is not obtain due to losses encountered in the steam network. To avoid these losses some mountings are used at the terminating points of the steam network. As steam is concert it is obvious that formation of condensate will also be there which helps in degrading the steam quality. Steam trap is one of the most important mounting used in industries to reduce the steam losses and maintain the quality of steam.

2. INSPIRATION

In each and every industry, process house is present in which number of steam running machineries are used weather it's a paper industry or any other industries. So it is very important to quality of steam by adding different mountings likes steam traps, non-returnable valves etc. In this project the main focus is on the steam traps.So the main problems which are faced in industries regarding steam traps are

- Float ball puncture.
- Steam leakage
- NRV (non-returnable valve) back
- Blocking of orifice
- Gasket leakage

These activities take lots of time in maintenance due to which the production get affected. The main aim of any industry is to do maximum production they can do but due to failure of steam traps. Failure of traps is the biggest hurdle which is to be overcome to optimize the maintenance timing as well as the production rate.

3. TERMINOLOGY

In this paper some keywords are used which are defined below for better understanding of the concepts

1. **Steam:**steam is a thermal liquid. It's a
2. **Steam Trap:** Steam Trap is a mounting which is used in mostly all of the steam powered industry. Steam trap is a device which is use to discharge condensate produced in the steam network as soon as it form.
3. **Orifice:** Orifice is a hole which is present inside the steam trap. It is basically the path through which the condensate get exit to the outlet.

4. **Pyrometer:** Pyrometer is an instrument which helps in measuring of the temperature. Laser radiations are used for measurement of temperature in pyrometer.
5. **Gasket:** Gasket is a wire gauge coated with rubber material. Gasket are used for the sealing if the steam traps to avoid leakage of steam.
6. **Condensate:** While traveling through the steam network, some quantity of steam get convert back into liquid form. This changed form of steam is known as condensate. Condensate degrades the quality of steam.

4. STEAM TRAPS

Function

The mechanism used in traps are that they permit the condensate to flow towards the outlet as soon as it forms and block the condensate. This is done by a small hole called orifice present at the lowest point. As steam condensate will collect at the lower point and live steam is obviously many times higher in volume as compares to this hot liquid, due to this condensate is effectively removed. The step vice operation of steam traps are as follows:

- The steam from the boiler is transferred through the pipelines to the desired place. In this process some amount of steam get condense out due to latent heat (enthalpy of evaporation).
- So to remove this condensate, at the terminating point of the pipeline steam traps are installed. The mixture (pure steam and condensate) enters the trap from the inlet of the trap.
- Due to relative weight of steam and condensate, steam moves upward and the condensate get collected in the lower part of the trap.
- As the quantity of condensate increases the orifice also get opened accordingly and the condensate is discharges.
- The orifice get closed as soon as the condensate is effectively removed.

The main function of the steam traps are as follow:

- To remove the condensate.
- It prevent back of condensate, so it also work as NRV (Non-returnable valve).
- It also work as an air vent.
- Minimizes the steam losses.
- It release unwanted gases like CO_2.
- It saves money by reducing maintenance cost.

Types

Steam Traps are mainly classified according to the mechanism of releasing the condensate through orifice into 4 major types, they are:

A. Ball Float Traps
B. Temperature Traps
C. Thermodynamic (TD) Traps
D. Venture Nozzle Trap
E. Balance Pressure Thermostatic Trap

Thermodynamic type (TD)

TD traps are used for distribution line. They are designed for applications where condensate load is less and intermittent. A 15 NB, thermodynamic steam trap with 4 $kg/cm^2(g)$ differential pressure will have a discharge capacity of 150 Kg/hr., while the load on main lines & header will not be more than 20 kg/hr. (on each trap) even during start-up.

Fig. 1: Thermodynamic traps

The most suitable steam traps for these applications is 15 mm TD trap with integral blow down cock (BD). This has a facility of on line trap cleaning using blow down cock. This is a modified version of TD trap. The trap has 3-orifice design enabling concentric seating of the disc to avoid wear and tear on one side and differential hardening between seat and the disc.

TD traps are designed to discharge condensate and entrapped air at steam temperature regardless of inlet pressure with no steam loss. The hardened seat and disc ensures long life. These traps are best suited for main lines or where condensate is less and intermittent.

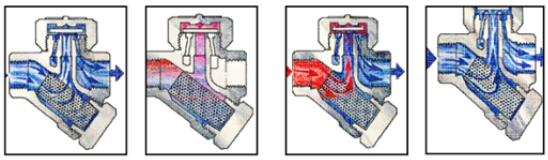

Fig. 2: Working of TD trap

On start-up, in coming pressure raises the disc and cooled condensate, plus air, is immediately discharged (A). Hot condensate flowing through the trap releases flash steam. High velocity creates low pressure area under the disc and draws it towards the seat (B). At the same time there is a pressure build-up of flash steam in the chamber above the disc which forces it down against the pressure of the incoming condensate

until it seats on the inner ring and closes the inlet. The disc also seats on the outer ring and traps pressure in the chamber (C).Pressure in the chamber is decreased by condensation of the flash steam and the disc is raised by the incoming pressure. The cycle is then repeated.

Ball Float Traps (FT)

BFTs are density operated traps and are designed to handle higher or continuous load. Their valve seats are always under water preventing steam loss. A separate air vent independently purges air giving a fast start up and discharges in parallel with the main valve seat without affecting its operation. These traps are best suited for process equipment i.e., heat exchangers, heating tanks etc. *Float traps have to be selected as per differential pressure across the trap and condensate load.* These traps also are available with Steam Lock Release (SLR) and automatic Air Venting facility (AV), which is ideal for this application.

During installation it should be noted that float traps should be installed with reference to the horizontal plane. If in any case the trap is tilted against the horizontal or upside down it results in the float not seating properly, hence steam leaks or water logging takes place. All "vendor", float traps are provided with arrow marks, which should point vertically downwards. The direction of flow is also marked on the body.

How It Works:

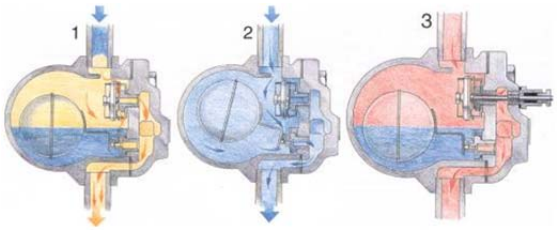

Fig. 3: Working of Float Trap

On start-up a thermostatic air vent allows air to by-pass the main valve (1) which would otherwise be unable to escape (a condition known as 'air binding')

As soon as condensate reaches the trap, the float is raised and the lever mechanism opens the main valve (2). Hot condensate closes the air vent but continues to flow through the main valve. When steam arrives the float drops and closes off the main valve, which remains at all times below the water level, ensuring that live steam cannot be passed.

All float traps must be installed properly. Arrow marks are provided that should point downwards in order to place the trap horizontal with reference to horizontal plane. If it tilts against horizontal or upside down, it results in the float not seating properly, hence chances of steam leak.

Selection

A float trap needs to be carefully selected. Float traps have differential pressure ratings of 4.5, 10, and 14 & above. Since most of the equipment operate at 5 kg/cm^2 (g) or below, model 15 FT 14-4.5 needs to be selected.Float traps also have automatic air venting facility (marked TV). Due to batch operation there are all possibilities of air entering inside float chamber, hampering its operation.

Balanced Pressure Thermostatic Trap (BPT)

Its operating temperature is affected by the surrounding steam pressure. The operating element is a capsule containing a special liquid and water mixture with a boiling point below that of water. In the cold conditions that exist at start-up, the capsule is relaxed. The valve is off its seat and is wide open, allowing unrestricted removal of air. This is a feature of all balanced pressure traps and explains why they are well suited to air venting

As condensate passes through the balanced pressure steam trap, heat is transferred to the liquid in the capsule. The liquid vaporises before steam reaches the trap. The vapour pressure within the capsule causes it to expand and the valve shuts. Heat loss from the trap then cools the water surrounding the capsule, the vapour condenses and the capsule contracts, opening the valve and releasing condensate until steam approaches again and the cycle repeats.

The differential below steam temperature at which the trap operates is governed by the concentration of the liquid mixture in the capsule. The 'thin-walled' element gives a rapid response to changes in pressure and temperature. The result is the response line as illustrated in **below graph**

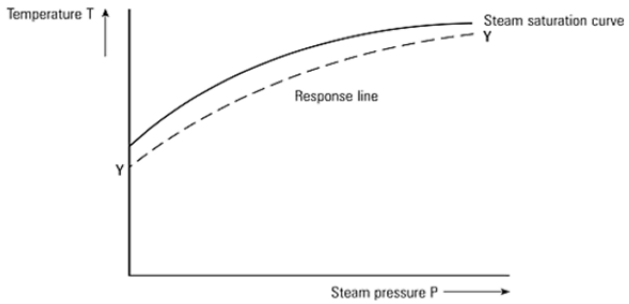

Fig. 4: Response of Balance Pressure Trap

Early bellows type elements of non-ferrous construction were susceptible to damage by water hammer. The introduction of stainless steel elements improved reliability considerably.

5. TESTING METHODS OF STEAM TRAP

Steam traps are checked by various method. These are the methods by which the traps are checked on daily basis by the workers or fitters. The methods are:

Visual Testing

According to the name it is very clear that only the observation done for the visual testing. The workers use to thoroughly check the traps without physically touching the trap. With the help of visual testing the steam leakage, condensation back, etc. are detected. For this testing some mounting or accessories like sight glasses, test tees, three way test valves, etc. are used. The outlets of the trap is left to check the flow rate of condensate discharge.

Sound Testing

In this the very minor sounds are checked by ultrasonic sound detector, screwdriver, etc. by the human ear. By this many kind of sounds like leakage of steam etc.

Temperature Testing

The most effective test is temperature testing. Temperature test is done by an instrument called Pyrometer. With the help of pyrometer the temperatures of the inlet and the outlet of traps are measured. A trap is said to be properly working when the inlet temperature of trap is greater by 10 or more from the outlet temperature. If the difference is not maintained by the then the trap is opened and the checking process or in other words maintenance of the trap is done.

6. RESULT

Table 1: Temperature of Traps under Experiment

TYPE	ORIFIC DIA.	INLET TEMP.	OUTLET TEMP.	CONDITION
FT	4.4	125	116	OK
FT	4.4	111.1	96.3	OK
FT	4.4	56.2	56.2	FAIL
TD	4.4	92.5	78.4	OK
FT	4.4	117	102.4	OK
TD	4.4	109.4	106.8	FAIL
TD	4.4	59.7	45.3	OK

Due to high pressure the ball float traps are having the problem of getting puncture frequently due to which the machine unable to run at the time of maintenance of traps. So in production get hamper and a large amount of time and money is spend on the maintenance purpose because a machine have number of traps in it and for repairing a single trap the machines are to be stopped as live steam is the working fluid.

7. CONCLUSION

There are number of different types of traps present in the market and having different mechanisms, different capacities and different models. So during the designing of the machine, the traps that are recommended should be tested under the required conditions. Selection of trap is the major part because according to the selection process the reliability of the trap as well as the machine depends. So the traps should be selected according to the usage.

8. ACKNOWLEDGEMENT

I am privileged to get an opportunity to do my research work in the support of my universityPoornima University. I would also like to thank the Mechanical department for giving me their full support and guidance. I would also like to thank the Trident Industry for giving me chance to do the experimental as well as the testing work in the industry. I would also like to thanks Mr. Ajay Verma, H.O.D. of mechanical maintenance in Trident Industry for guiding me during my experimental work on steam traps as well as all the workers of this industry for cooperating with me during that duration.

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